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A STUDY ON CHARACTERS OF POLYETHYLENE TEREPHTHALATE FIBER REINFORCED EPOXY NANO COMPOSITES

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ABSTRACT :- An economical and viable option to conventional and high cost materials is the use of fiber glass/epoxy composites, but for impact applications their toughness still has to be enhanced. The toughness and other mechanical properties can be improved by using very small amount of PET into an epoxy system. In the present work epoxy modified with MMT Clay (3 wt % of Epoxy) & PET fiber is manufactured using hand layup method. The nano composites have been characterized using Impact, Tensile, Bending and Microhardness tests. The mechanical properties are compared with those found for PET introduced epoxy nano composites. The mechanical test shows that the presence of 1 wt% PET fiber largely increases impact strength and flexural strength. Micro hardness decreased at PET fiber loading.

KEYWORDS :- PET -Polyethylene Terephthalate, WT-Weight, ASTM- American Standard Test Method.

I. INTRODUCTION

In 1946, the first industrially-produced epoxy resin was introduced to market. Since then, the use of thermosetting polymers has steadily increased. The wide range of epoxy resin applications includes: coating, electrical, automotive, marine, aerospace and civil infrastructure as well as tool fabrication and pipes and vessels in the chemical industry. Due to their low density of around 1.3g/cm and good adhesive and mechanical properties, epoxy resin became a promising material for high performance applications in the transport industry, usually in the form of composite materials such as fiber composite or in honeycomb structures. In the aerospace industry, epoxy composites material can be found in various part of the body and structure of military and civil aircrafts, with the number of applications on the rise.

The term epoxy resin refers to both the polymer and its cured resin/hardener system. The former is a low molecular weight oligomer that contains one or more epoxy groups per molecule (more than one unit per molecule is required if the resultant material is to be cross-linked). The characteristic group, a three-member ring known as epoxy, epoxide, oxirane, glycidyl or ethoxyline group is highly strained and therefore very reactive. Epoxy resins can be cross-linked through a polymerization reaction with a hardener at room temperature or at elevated temperature (latent reaction). Curing agents are used for room temperature cure are usually aliphatic amines, whilst commonly used higher temperature, higher performance hardener are aromatic amines and acid anhydrides. However, an increasing number of specialized curing agents, such as poly-functional amines, polybasic carboxylic acids, mercaptans and inorganic hardener are also used. All of these results in different, tailored properties of the final polymer matrix. In general, the higher temperature Cured resin systems have improved properties, such as higher glass transition temperatures, strength and stiffness, compared to those cured at room temperature.

II . MATERIALS

Montmorillonite Clay:
Clay as nano particles such as Semitic clays (Montmorillonite) are incorporated into polymers to form resulting polymer nano composite, which may possess unique electrical, mechanical and optical properties.

Polyethylene Terephthalate (PET):
Polyethylene Terephthalate, commonly abbreviated as PET, PETE or the obsolete PETP or PET-P, is a thermoplastic polymer resin of the polyester family and is used in synthetic fibers; beverage, food and other liquid containers; thermoforming applications; and engineering resins often in combination with glass fiber.

Recron fibers PET (Poly ethylene Terephthalate), Diameter - 15µm, Length – 3mm are sold by Reliance India Ltd.

Epoxy Resins & Hardener:

Epoxy resins, also known as epoxide resins, are a class of polymers, containing reactive groups which are converted to thermosets resins by reaction with compounds known as curing agents

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Mbrace Saturant Epoxy Hardener
Appearance Blue translucent liquid Clear, colour less to slight amber low viscosity liquid
Specific gravity 0.950 - 1.150 g/cm3 at 23ºC 0.96 - 1.00 kg/L at 23ºC
Solubility in water Insoluble Insoluble Hydrophobic.
Boiling point/ Flash point > 200ºC > 100ºC

III. EXPERIMENTAL METHODOLOGY

Mixing of Nanoclay into Epoxy (base):

Preparation of Nanoclay: Before mixing the Nanoclay into the epoxy base, Nanoclay was dried at 1200C for 2 hours in a vacuum oven.

Mechanical stirring: Epoxy base is a blue colour thick fluid. It is quite difficult to mix nano silicates into it manually. So we used a mechanical stirrer and an oil bath for proper mixing of nanoclay. Oil bath was used to heat up the epoxy to desired (800 C) temperature, so that the viscosity of epoxy base is reduced. Proper mechanical stirring of epoxy at this stage resulted in a better dispersion of clay. Weight percentages of clay 3 % by weight of epoxy, were added and stirred at a temperature of 800 C for 1 hour.

Ultrasonication after Mechanical Stirring: Sonication is an act of applying sound energy to agitate particles in a sample, for various purposes. In the laboratory, it is usually carried out using an ultrasonic bath or an ultrasonic probe, colloquially known as a sonicator. Sonication can be used to speed dissolution, by breaking intermolecular interactions. Sonication was done for evenly dispersing nano particles in liquids. After mechanical stirring of the epoxy solution container was placed into the ultrasonication bath for up to 3 hours at 300 temperatures.

Preparation of PET Fibers: In order to improve the adhesion between the fiber and the matrix, the PET fibers were subjected to alkaline hydrolysis. The fibers were treated with a NaOH aqueous solution (50% w/v) at 800C for 2.5 min., then fibers were washed with distilled water until all the sodium hydroxide was eliminated and the water used for washing the fibers no longer gave any alkalinity reaction. Subsequently, the surface-treated fibers were dried at 600C for 24 h in a vacuum oven.

Mixing of Epoxy Base solution with modified treated PET fibers:After ultrasonication, PET fibers mixed into the solution in different ratios (0, 0.25, 0.5, 0.75 & 1% by volume). After mixing, manual stirring up to 5 to 10 minutes was done.

Mixing of Epoxy Base & PET Solution with Hardener:

After ultrasonication, the solution is mixed with the hardener in the ratio 10:4 by volume. After mixing, manual stirring for 5 to 10 minutes was done.

Making the PET/Epoxy Composite Sheets:

The mixture was then poured into the mould and applied uniformly using the hand layup method. Due to low viscosity, the solution maintained uniformity by self. After applying epoxy, the sheet was left overnight to dry. The full curing of sheet was done by leaving it under ambient temperature for at least seven days before processing further.

Specimen Specifications:

The dimensions of specimens are shown below.

Table 1: Specimen Specifications for Testing

Parameter for Specimen	Specimens for Tensile Testing	Specimens for Impact Testing	Specimens for Bending Testing
Length	125 mm	62 mm	125mm
Width	15mm	10 mm	12.7mm
Thickness	4mm	4mm	4mm

IV. RESULTS & DISCUSSION

1. Micro-Hardness Results:

The micro-hardness of specimen at different PET loadings was measured. Fig 1 shows the experimental measurements of micro hardness of the nano composites with different PET contents. An average hardness was calculated by 3 indentation measurements and a plot of the results of each type of samples is shown in graph 1.

From the graph it has been observed that as we increase the loading of PET the microhardness of the nanocomposite decreases when the PET loading is increased from 0% to 0.25% the microhardness decreases abruptly but when we increase content further form 0.25% to 0.5% we see average in decrease in microhardness but less as compared to previous one. As we further increase the PET content to 0.75% we observe very less or least decrease in microhardness. Further increase in the PET content to 1% the microhardness decreases to 16.11415. So from the above discussion we can say that the microhardness of the nanocomposite

decreases 25% as we increase the PET content up to 1% by weight. The reason for this may be that PET fiber being a thermo plastic is a soft material and epoxy being the thermo setting material is a very hard material.

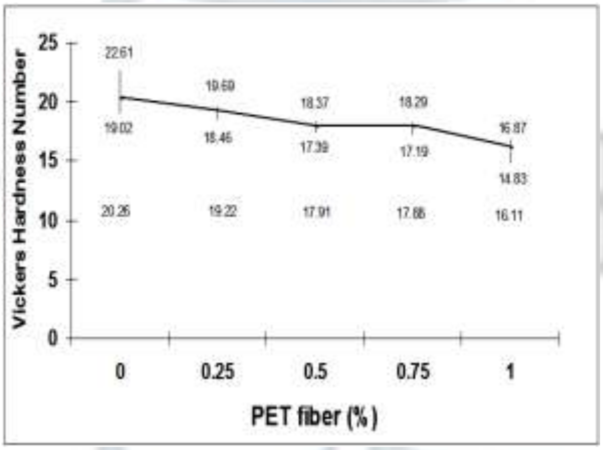

Fig 1: Micro Hardness test Results

2. Tensile Test Results:

Tensile test it has been roughly observed that as we increase the percentage of PET the tensile strength of the nanocomposite also increases. In the graph 2, we can see that as we increase the PET content from 0% to 0.5% the tensile strength increase at very high rate that is very beneficial for the manufacturing of strong material product shows. As we further increase the PET percentage to 1% the tensile strength increases at the low rate as compared to above one. An optimum concentrate of PET fiber of 0.50% is clearly observed from fig 2.

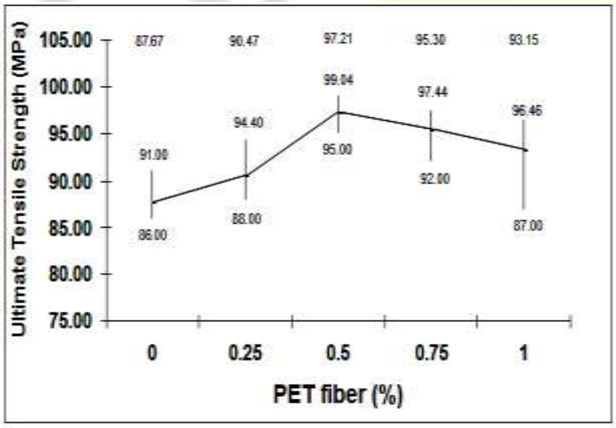

Fig 2: Ultimate Tensile Strength vs PET fiber %age

3. Bending Test Results:

Fig 3 shows the results that are observed in the bending test on the test samples of different loading of PET fiber in it. We take five samples for each composition, but we take average of only three best results.

From the fig 3, it can be seen that the bending strength of the nano composites increases as we increase the percentage of PET. So we can say that improve the bending strength property with increase the %age of PET contents.

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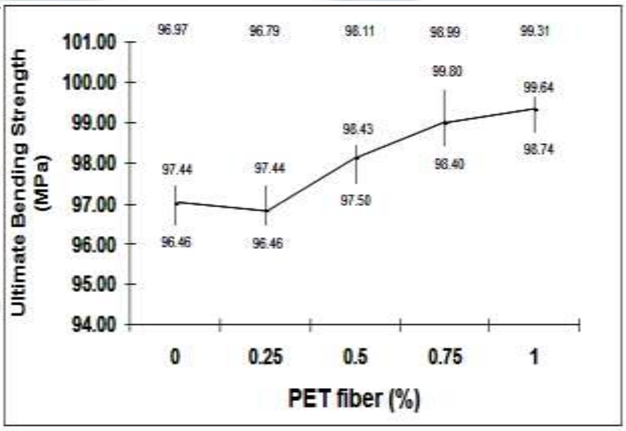

Fig 3: Bending Strength vs PET %age

V.CONCLUSIONS AND FUTURE SCOPE

PET introduced nano composites have been manufactured using epoxy as matrix. PET was added to epoxy in different weight percentage (1 wt%, 0.75 wt%, 0. 5 wt%, 0.25 wt % & 0 wt% of weight of resin). For the processing of epoxy-PET mechanical stirring and ultrasonication was done. The composites were manufactured using hand layup method and characterized using Tensile, Bending, Microhardness & Impact Tests. Tensile, bending and Impact tests were performed on nano composites as per ASTM standards.

It was found that the hardness of the nano composites decreased with increasing PET content. The Tensile strength of the sample piece increases with the increase in the PET content, but after 0.50 wt% start decreases the tensile strength. Bending strength firstly decreases as we increase the PET strength to 0.25 wt% & after that the bending strength increases as we increase the PET content. Impact strength increases with the increase PET content.

Future Scope

The experiment can be performed on polyester as matrix system, since with this matrix the barrier properties of composites can be enhanced. Clay loading can also be varied more than 3 wt%. The duration of current experiment can be increased to see the effect in long term. PET loading can be increased to 2-3 wt% if PET loading is done mechanically. PET stickiness can be increased to large extent by washing the PET fiber for more time in NaOH, to get other properties.

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